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FINAL TECHNICAL REPORT

ALTERNATIVE PROGRAM APPROACHES FOR THE ADVANCED SATELLITE TECHNOLOGY PROGRAM

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FINAL TECHNICAL REPORT

ALTERNATIVE PROGRAM APPROACHES FOR THE ADVANCED SATELLITE TECHNOLOGY PROGRAM

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The contractor has examined the feasibility of various ASTP concepts.

ADVANCED SATELLITE TECHNOLOGY PROGRAM

EXECUTIVE SUMMARY

Science Applications International Corporation (SAIC) has examined the feasibility of various concepts for the Defense Advanced Research Project Agency (DARPA) Advanced Satellite Technology Program (ASTP). The concept that is the most likely to be supported by the operational community, and least able to be opposed by the traditional space community, is one for which a trans and post SIOP survivability requirement can be justified. The most important technology that must be demonstrated is one that helps control satellite development costs, and launch preparation costs. Because the ASTP has a very ambitious program schedule, and a very complex program, DARPA should give serious consideration to running the program with a much higher level of Systems Engineering and Technical Assistance (SETA) support than is normally used on DARPA programs.

1. INTRODUCTION

The DARPA's Advanced Satellite Technology Program (ASTP) has three basic objectives: 1) ~~The first is~~ to create a set of low-cost, lightweight satellites; 2) ~~The second is~~ to create a low-cost launch capability to be used with the lightweight satellites; 3) ~~The third objective is~~ to demonstrate military utility for the satellite system to a broad class of tactical as well as strategic operational military commanders. This demonstration will include providing the low-cost satellites on-orbit that perform the required military function, assuring a means of access to space for that satellite across a wide range of conflict scenarios, and integrating the ground support necessary to achieve the military utility objective. The technical approach to achieve the low-cost, lightweight satellite objective requires a combination of technology development and prototype development. The term prototype, as used in this report, implies a state of program maturity beyond that of a successful on- orbit technology demonstration, but short of the complexity of a full scale system development. The development program will include a number of on-orbit technology demonstrations to support engineering tests and to demonstrate military utility. The culmination of the program is to show that the objectives have been reached by on-orbit demonstrations within a five-year schedule. Managerial and technical approaches will be discussed to accomplish the ASTP objectives within the cost and schedule constraints. The DARPA roles are compared with an associated estimate of the SETA effort required for each alternative approach. For each element of the program, the SETA requirements are identified. In addition the report includes a discussion of what is required to implement the plan with DARPA as the lead, with DARPA in a support role, or with DARPA as the system oversight organization. The approach in which DARPA delegates the program authority completely and has limited influence over subsequent events is not addressed.

The following paragraphs address the strategic concepts and programmatic issues required to achieve the objectives described above. The examination of the strategic concepts will be made in the context of four situations: new missions, or new ways to do old missions; reconstitution; accelerated space technology transfer; and assured access to space.

2. ASTP CONCEPTS

2.1 New Missions, or New Ways To Do Old Missions

The satellite that has been selected to discuss the ASTP in the context of the "new mission" category is one that will be referred to in this report as DATASAT. The operational concept for DATASAT is that the satellite will be transmitted a data base through an up-link when it passes over the CONUS. When it passes over the designated theater, DATASAT will transmit appropriate portions of the data base to the ground stations. It is useful to examine the utility of DATASAT across a spectrum of conflict to gain additional insight into the characteristics that should be designed into the satellite. The utility of DATASAT will depend to a large degree on the nature of the data base which it distributes. At the unclassified level it is difficult to be absolutely definitive in the assessment of DATASAT utility as a function of conflict. Therefore, the reader with more information access should consider the following analysis in the context of that additional information. In time of peace, DATASAT will have modest utility. The information it handles would be of limited value, and could surely be distributed much more economically by other means. In the course of dealing with an outbreak of terrorism, DATASAT could have a somewhat higher utility. The amount and type of data required would be limited, and once again, other, more economical means of data dissemination exist. The utility of DATASAT in low intensity conflict would depend on the level of intensity. During the early days of the Vietnam War DATASAT would have had low utility. However, as the intensity increased to the level of daily fighter raids on North Vietnam, and finally to the employment of strategic bombers over North Vietnam, one can conceive of a data base for which daily updates could be moderately useful. DATASAT would have high utility during limited war and general war. There are a number of different data bases which could be of high utility for commanders of land, sea, and air forces. Clearly, these data bases would benefit from frequent updates. If the general war was waged short of nuclear sanctuary exchanges, it could be assumed that the means of obtaining, processing, and up-linking the data to DATASAT would continue to exist. However, in the trans and post SIOP environment, one would have to assume that these capabilities would be destroyed.

Although the utility of the data could be high in the post SIOP environment, the DATASAT system itself would have low utility unless heroic, and extremely expensive measures were taken to insure the survivability of the CONUS ground portion of the system. The DATASAT system has its maximum utility in the upper level of low intensity conflict, across limited war, to general war below nuclear sanctuary exchange levels. The implication of this outcome is that launch and reconstitution of DATASAT can be planned for existing launch facilities. The substantial additional expense of providing post SIOP assured access to space can be avoided. The difficulty with the DATASAT concept is that the traditional space community could argue that the DATASAT mission could be handled by existing classes of satellites, and that a LIGHTSAT is not required. This attitude among the traditional space community complicates the problem of building programmatic support for a DATASAT concept with the DoD, or the Congress even though the concept is technically feasible and operationally desirable. One of the reasons that conventional satellites could be considered for the DATASAT mission is the fact that for 35 years the United States has developed its military force structure with the "Central European Scenario" in

mind. So it would not be inconceivable to place a satellite system in orbit, optimized to service that theatre's needs. However it would not seem possible to predict the need for the ability to perform a number of the missions currently performed from space over the Falkland Islands, Grenada, Libya. or the Straits of Hormuz. So one of the "new" missions that the ASTP should concentrate on is a contingency capability to do one of the classical satellite missions, on short notice, anywhere in the world. In this context it is not necessary to argue the survivability question because of the low level of conflict intensity. This would seem to be a mission that could be the exclusive domain of the LIGHTSATS. To build programmatic support one would have to only justify the need for the capability, it would not be necessary to confront the traditional satellite community. The notion of "new ways to do existing missions" must be approached very carefully to avoid the natural reluctance of the government and the associated contractor structure to change a presumably successful way of satisfying the mission requirements. One of the key considerations that could cause the operational commanders and the Congress to support the concept would be the survivability issue, particularly trans and post SIOP. The American military services have always attempted to follow the the principle that they will train the way they will fight.

If they can not count on a capability in wartime, they have no utility for the system in peacetime. ASTP, for the first time, has the potential for assuring the existence of a warfighting capability in the trans and post SIOP environment It seems likely that the only way to get the programmatic support to do an "existing mission a new way " is to focus on a system embodying the survivability/warfighting capability.

2.2 Reconstitution

Reconstitution in the context of the ASTP is the concept where a lower cost, possibly lower capability, LIGHTSAT is prepared as part of a conventional satellite program. When an on-orbit failure occurs with a primary satellite, the LIGHTSAT back-up could be quickly launched to restore part or all of the mission capability. It would not appear to be advantageous for ASTP to consider this concept for the LIGHTSAT application. Once again the concerns are programmatic not technological. It is very likely that the program office building the primary satellite the traditional way would argue that the LIGHTSAT portion of the budget should be allocated to the primary satellite either to raise its reliability, or its survivability. It may be possible to consider a LIGHTSAT reconstitution satellite as part of the initial program planning for a new satellite program, but it still seems to be one of the less promising opportunities for the ASTP concept.

2.3 Accelerated Space Technology Transfer

This concept was introduced as a way of gaining support for the ASTP from the traditional space community. The ASTP will undoubtedly prepare and launch a number of demonstration satellites in the course of the development program. A number of these launches will be intended to demonstrate technology specifically required by the LIGHTSAT concept. However, the low cost satellite and launch capability developed for these demonstrations may provide significant opportunities for space technology launches in general. Every year the space technology community submits requests for opportunities to experiment on orbit. These requests are reviewed by a tri-service committee, and the details of the

approved experiments are published annually by ANSER Corporation. The current document is entitled, Space Technology Division Note, STDN 87-9, Report of The Space Test Program Experiments Review Meeting, 12-13 May 1987. This document contains significant technical detail for each of the approved experiments, such as the requirements for weight, volume, power telemetry data rates, pointing, tracking and cooling, to name a few. It could be politically useful in the early design stages of the ASTP to consider the range of requirements for these space technology experiments. DARPA could build a group of supporters for the ASTP program at the same time executing a traditional DARPA role, enhancing technology transfer.

2.4 Assured Access To Space

This capability does little to support the ASTP concept at the lower levels of intensity of conflict. However, at the theater level it could be an important concept. In the trans and post SIOP arena this could be the requirement that is the single most important reason for pursuing the ASTP. A LIGHTSAT could provide the only trans and post SIOP capability available in its particular arena of operation. This area in which ASTP is the dominant concept, will have serious program implications. The satellite architecture will have to be designed from the beginning to have a survivable ground station. This may involve providing a substantial autonomous capability to the satellite in order to allow for a more simple, survivable ground station. The second consideration is that the satellite size weight and orbit may be constrained by that which is capable of being launched from a facility that can survive a full scale nuclear attack. One approach is to design the satellite to be launched from a missile tube on an SLBM. The programmatic implication of these points will be explored further in the Satellite and Launcher sections of the report. The capability for assured access to space may the most important issue in terms of providing programmatic support for the ASTP. It will line up the operational commanders and the Congress as supporters, and neutralize the opposition from the traditional satellite community who can not satisfy such a requirement.

2.5 Satellite

The satellite itself, has two components: the satellite bus and the payload. Satellite bus technology has been proceeding and already may be adequate for this program. However, it may be necessary to conduct a number of on-orbit demonstrations to "space qualify" a given technology before it can be incorporated into a prototype. If so, the primary effort will be selection of the satellite bus and contracting for production of the required number of buses to support the engineering flight tests and on-orbit technology demonstrations. This assessment should be verified in the early stages of the program. Payload technology also has been proceeding but may be incompatible with the selected satellite bus technology. The current contracting method for satellite acquisition provides latitude within the contract to design and build both the satellite bus and the payload and to integrate the two parts. A new contracting method may be required to develop several types of payloads that must be compatible with the same satellite bus. Modular approaches may be applicable to the satellite bus to support a variety of payloads. This approach will require careful definition and management of the interface between the satellite bus and payload.

2.5.1 Satellite Contractors

There are two choices of contracting for the satellites. The satellite bus may be provided GFE to the payload contractor who integrates the bus and the payload. Alternatively the government may contract separately for the bus and the payload and perform the integration itself. In either event a fundamental quandary exists. In order to successfully build, launch, and operate a satellite system it will be essential to deal with an experienced space contractor. Even when experienced space contractors are used, and long, involved development processes are followed, on-orbit failures are all too frequent. It would probably be disastrous to attempt to do this program with contractors, on any phase of the program, who were not "space experienced." On the other hand the ASTP seeks to create a new way of doing business in space. Extreme care must be exercised to prevent the inadvertent introduction of "business-as-usual" concepts from the contractors who have significant experience with space systems. Several suggested new approaches are included below as examples of the kind of new space thinking that must be followed by the space experienced contractors selected for this program. The current method of contracting requires operation in orbit for a predetermined period of time to meet the contract requirements. This, in turn, requires ground system support for telemetry processing to certify correct operation of the satellite. A method of contracting that provides a "best effort" satellite bus and payload may alleviate the costs of the satellite acceptance process for low-cost satellites. Another low-cost satellite approach relates to disposal at the end of the mission. The current low earth orbit satellites require a restartable engine to maintain the perigee altitude during the mission and to terminate the mission by de-orbiting the satellite in the broad ocean area. The low-cost satellites could be designed to be destroyed during reentry to avoid the extra weight and cost of the restartable engine and the propellant. The examples given above are representative of existing requirements that may be relaxed to achieve the low-cost, lightweight satellites. Considerable effort should be given to requirements analysis to separate out the "folklore" requirements from the real requirements for lightweight satellites. DOD-HDBK- 343 (USAF) Design, Construction, And Testing Requirements For One Of A Kind Space Equipment, 1 February 1986, (Attch 1) represents a first attempt to control the various satellite program requirements as a function of the size, complexity, cost, mission, and intended on-orbit duration. It has been coordinated with various DoD laboratories, and published by USAF Space Division. The handbook addresses design, construction, documentation, testing, and review requirements for four different classes of space systems.

It describes the space program characteristics and how they should be varied as a function of the four different classes, including detailed citing of DoD and NASA standard documents. This handbook represents an excellent starting place for the ASTP to attempt to develop a "new way of doing space business", and should be included as part of contractual relations with the various contractors on the program. It is important to acknowledge that what is being attempted in the ASTP program is the creation of a new "space culture" in the U.S. space community. Although it is intended that the "new space culture" will coexist with, rather than replace, the existing space culture, many obstacles will have to be overcome. Initial costs for research, engineering, and development may have to be increased, if necessary, to successfully build and demonstrate space systems that minimize the recurring unit costs. If the initial costs are not sufficient to demonstrate a new way of successfully doing business

in space, it will probably be impossible to modify existing attitudes, and the program will fail.

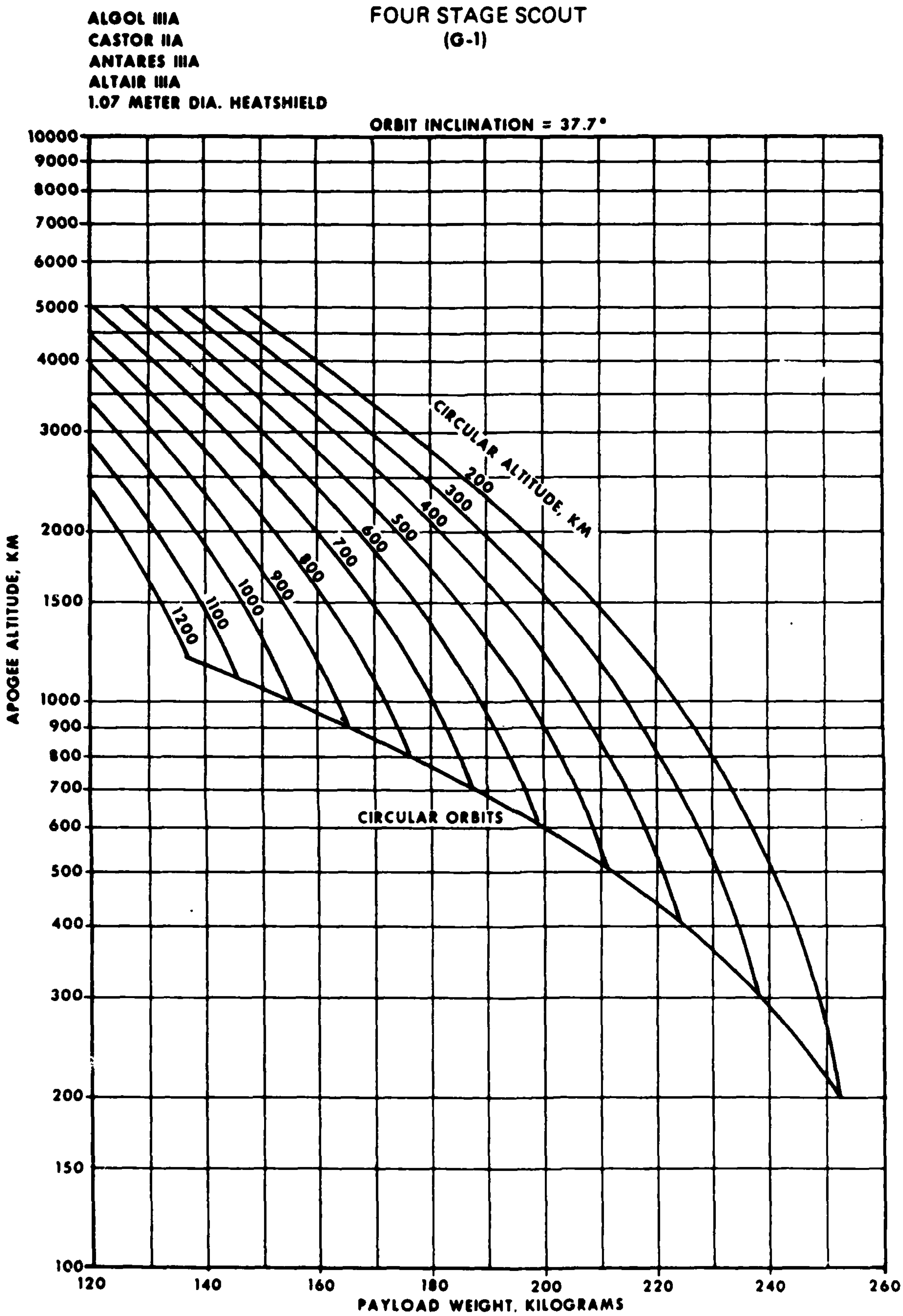
2.6 Low-Cost Launchers

The approach required to achieve low-cost launchers for lightweight payloads may be the most significant near-term technology issue. The commercial launcher market tends towards heavier payloads so the private sector may not support development of launchers for lightweight satellites. The private sector should be encouraged to take their current approach and apply it to the development of a low-cost launcher for lightweight satellites. Some effort may be required to convince the private sector that a sufficiently large market exists for the launch of lightweight satellites. To be cost effective, the organic launch capability will require simple launch procedures with a small crew. Therefore, the technology for low-cost launchers must be accompanied by low-cost launch support. The current costs for launch pad support are prohibitive, even if the low recurring unit costs are reached for the launchers themselves. The launchers should be designed for low manufacturing costs and for minimum launch support costs to minimize the cost of ownership over the lifetime of the launchers. One possible trade-off for launchers is to combine the upper stage with the satellite bus, as was done many years ago with the AGENA program. This requires analysis of the interface between the launcher and the satellite to determine if upper-stage performance and weight can be allocated to the satellite bus instead of the launcher. Since several of the satellite bus subsystems are duplicated in the upper stage of the launcher, an opportunity may exist for weight and cost savings. The subsystem to separate the launcher upper stage from the satellite bus also can be eliminated with this approach.

An existing launch system that could be used for early demonstrations is the Four Stage Scout, produced by the Missiles Division of LTV Missiles and Electronics Group. As shown in Figures 1, 2, and 3, extracted from the LTV SCOUT Planning Guide, the Scout could place at least 450 pounds, into at least a 100 NM orbit with a number of different launch locations and orbital inclinations. This data can be used as a lower bound on the size and weight for the ASTP satellites, since as new launcher technology is developed it will presumably result in the development of launchers more capable than the SCOUT. The planning for the launcher portion of the program should incorporate SCOUT in the early launches, and then phase in the new launcher technology as it becomes available. If the satellite concept chosen for early development incorporates the requirement for assured access to space across the entire spectrum of conflict then the satellite must be designed so that a survivable system is possible. It will be necessary to demonstrate through design studies that the satellite could for example be launched out of a submarine's missile tube. It should not be necessary to demonstrate this capability nor to actually modify a sub based missile until the LIGHTSAT concept goes into full scale development. As part of a full scale development program the survivable launch capability must be demonstrated.

2.7 Demonstrating Military Utility

Achieving the military utility objectives requires two separate efforts. The first effort should address the payload technology to perform the required functions for the military user, including strategic as well as tactical, operational commanders. The second effort should address the ground

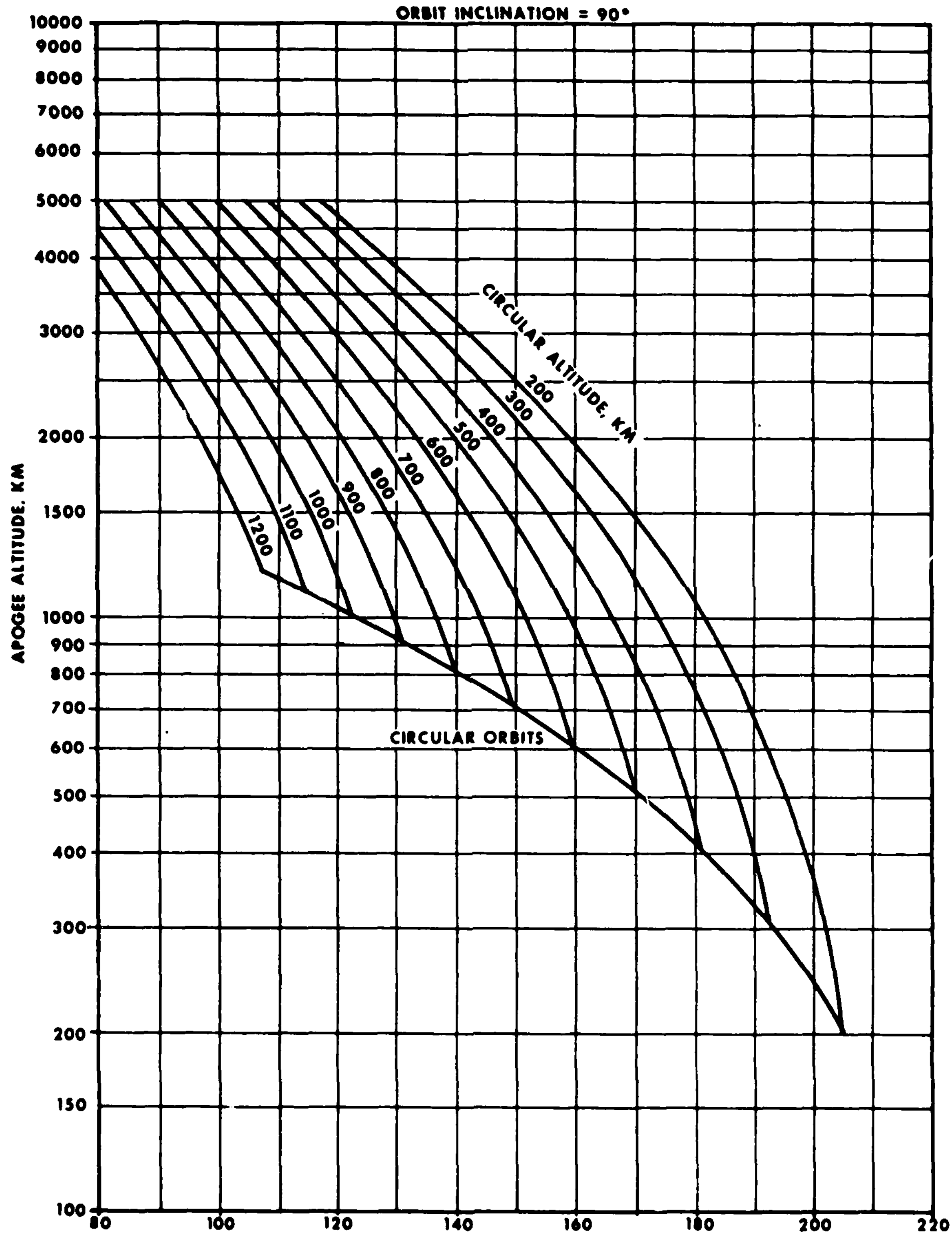


ELLIPTICAL ORBIT PERFORMANCE – WFF

Figure 1

ALGOL IIIA
CASTOR IIA
ANTARES IIIA
ALTAIR IIIA
1.07 METER DIA. HEATSHIELD

FOUR STAGE SCOUT
(G-1)

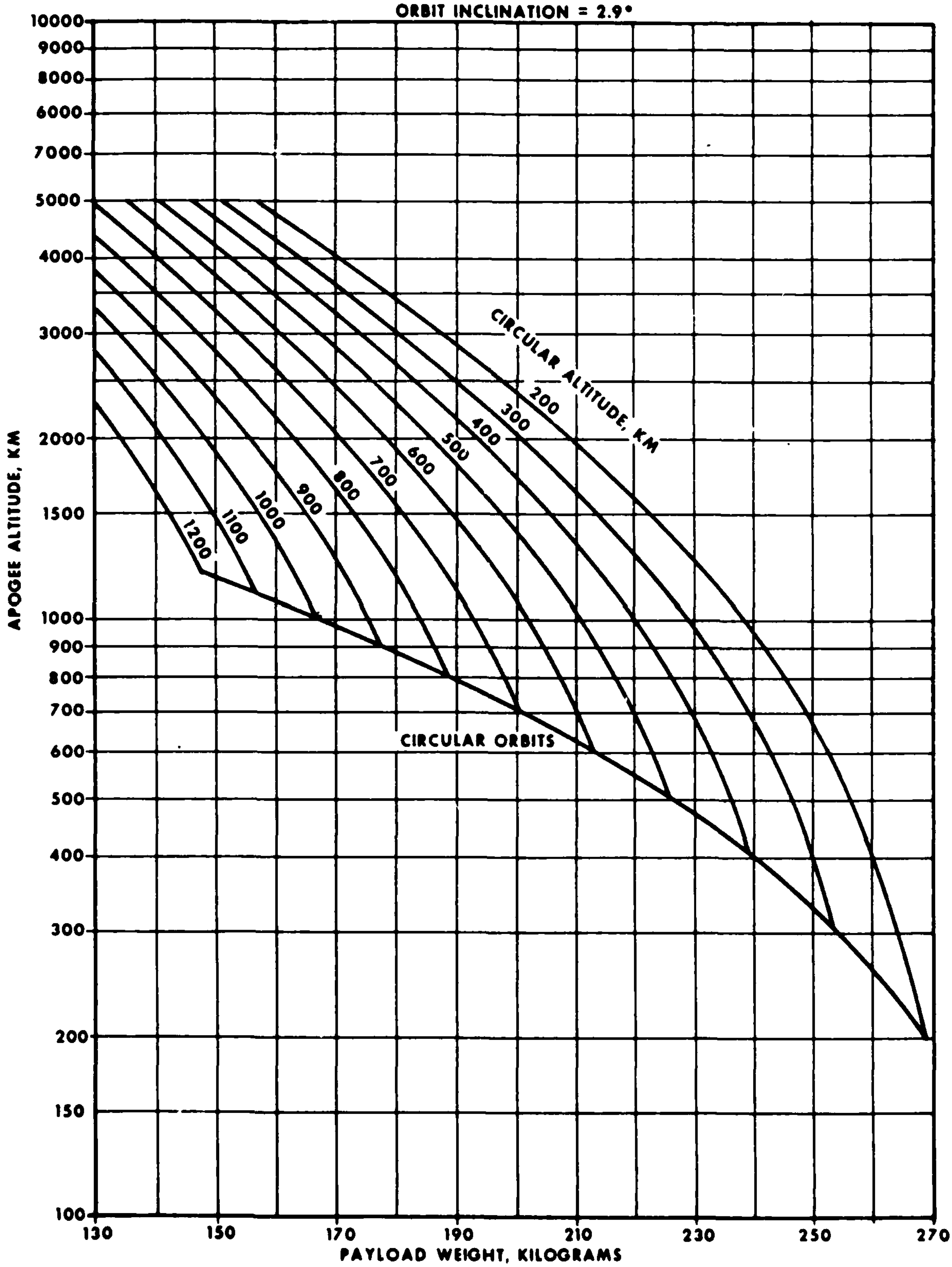


ELLIPTICAL ORBIT PERFORMANCE – VANDENBERG AFB

Figure 2

ALGOL IIIA
CASTOR IIA
ANTARES IIIA
ALTAIR IIIA
1.07 METER DIA. HEATSHIELD

FOUR STAGE SCOUT
(G-1)



ELLIPTICAL ORBIT PERFORMANCE – SAN MARCO

Figure 3

support under the military user's control that receives and processes the satellite data. The ground support includes the mission tasking and support of the satellite in orbit, as well as the transmission, reception, processing, and dissemination of the payload data. The satellite designs can be constrained to interface with existing ground processing systems for the on-orbit technology demonstrations to minimize ground system modifications. This may not be the actual long term solution for prototype development, but it may be sufficient for demonstration of the military utility. The mission tasking must be shown to be responsive to the military needs during the demonstrations. The on-orbit technology demonstrations should be planned to perform each of the functions needed by the military users. The prototype nature of the demonstrations need not address the operations transition issues for operational systems, but some documentation and training effort may be required to use military resources for the demonstration support.

Based on the probability that not all objectives will be met in one flight, several flights should be planned with a period of time provided between flights for implementation of engineering and operations concept changes. Two or three flights for each payload type should be sufficient to assess the utility.

3. TECHNICAL APPROACH

In light of the previous information it is necessary to refine the strategic concepts, and to incorporate the strategic, political, and programmatic information into a technical approach for the ASTP. The technical approach for the ASTP requires parallel efforts in six areas: program management, systems engineering, technology development management, prototype development management, system integration, and on-orbit technology demonstration management. The DARPA role in these areas can be either retained or delegated. Each of these areas is discussed in the following paragraphs.

3.1 Program Management

The program management role requires program planning and program control. There is a close relationship between the planning and control functions to ensure timely replanning, as required during the program.

3.1.1 Program Planning

Program planning is required for preparation and maintenance of the ASTP Program Plan and the ASTP Technology Development Plan. Each of these plans must be prepared early to establish the basis for implementation. The program plan addresses the technology and prototype development issues, assigns the roles and responsibilities for implementation, and identifies the on-orbit demonstrations to be supported by the program. The technology development plan identifies the technology needs that must be transferred to prototype development during the program to meet the objectives. Program planning requires life-cycle cost estimation and integrated program scheduling to support initial definition of the program and to maintain current program status. A typical schedule for one payload is shown in Figure 4. All program activity stems from these plans, and both plans must be maintained current during the program to permit review of program status versus the plans. Subsequent manpower estimates in this report will depend on detailed analysis of this schedule.

3.1.2 Program Control

Program control is required during implementation to ensure that the plans are being followed and that technical progress is meeting expectations. Program control requires development status monitoring, configuration management, and data management tasks to establish the program basis initially and to maintain it through completion of the program.

ASTP is an unusual technology program in that it must have the discipline of full-scale development to meet the flight readiness reviews for the on-orbit technology demonstrations. Seven separate elements must be developed for each demonstration, and the elements must be integrated into an almost operational configuration to evaluate the military utility. Program control must coordinate these activities and anticipate potential problems. Development status is provided to the integrated program scheduling task to assess current status and forecast future status.

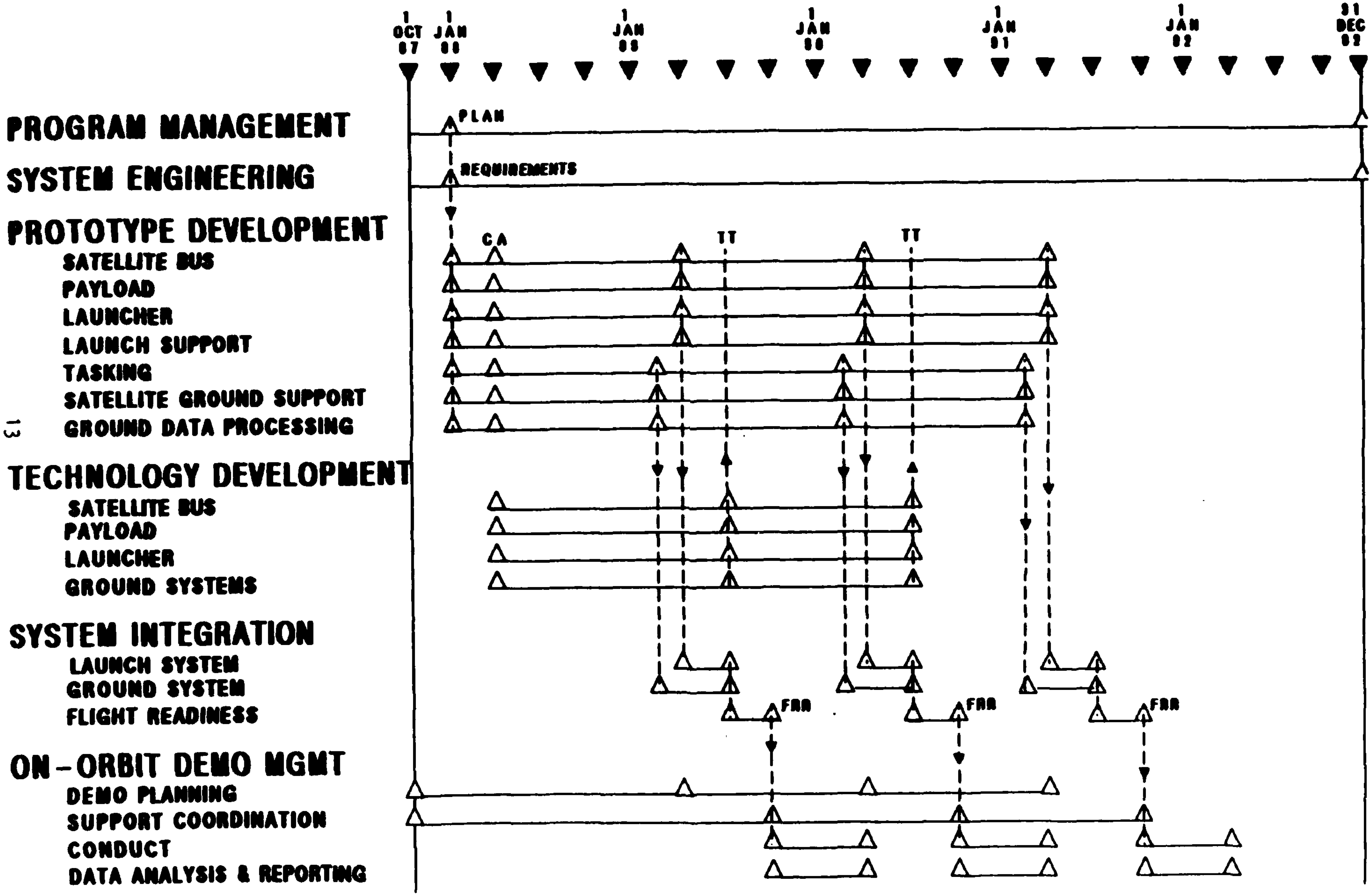


Figure 4. Typical ASTP Schedule

3.1.3 Roles and Responsibilities - Program Management

Management of the overall program is currently a DARPA responsibility. To ensure that the program uses innovative approaches to address the program issues, DARPA should provide the leadership by retaining management of the program. If the program management is delegated to an organization, such as the Space Test Program at the Air Force Space Division, it may be difficult to use innovative approaches in that environment. The program control includes the program oversight of cost and schedule. Delegation of the lead-in program management while retaining the systems engineering role may result in two program oversight functions: programmatic and technical. Separate programmatic and technical responsibilities are seldom used in complex development programs such as ASTP.

3.2 Systems Engineering

The systems engineering role requires system analyses to establish the system requirements for each payload and launcher type and to assign the requirements to the various elements of the on-orbit demonstration. In addition, the systems engineering role requires strong participation by the SETA contractor at all design reviews to ensure that the assigned requirements are being met and to recommend corrective action to the ASTP Program Manager. The systems engineering role includes a program technical oversight function to support contingency planning and minimize system impacts when program problems are encountered.

3.2.1 System Analyses

The analyses required in the systems engineering role are system analyses, mission analyses, system effectiveness analyses, and detailed requirements analyses. These analyses must be performed early in the program to ensure that the system requirements satisfy the military utility objective and that the requirements are assigned correctly so that the parallel development efforts will converge for the on-orbit technology demonstrations. These analyses must be repeated for proposed changes or for replanning to ensure that the compatibility and utility are preserved.

3.2.2 Technical Reviews

Active SETA participation at all technology demonstration and prototype technical reviews is required to ensure that the designs will meet the assigned requirements. Also, the identification and control of cost drivers is important during the prototype development to achieve the low-cost objective. The reassignment of requirements based on reduction of cost drivers requires sustained systems engineering effort throughout the design and development of the system.

3.2.3 Technical Oversight

Technical oversight of the program activities is required to ensure that the objectives will be reached by pursuing the planned course of action. When contingency planning is required, the systems engineering staff is responsible for recommending changes to the ASTP Program Manager to minimize the impacts on the system's ability to meet the objectives.

3.2.4 Roles and Responsibilities - Systems Engineering

The systems engineering function should be retained by DARPA. The skills required in the systems engineering role are similar to ones required for the program management role. If one is delegated separately from the other, it may require additional highly skilled resources. Furthermore, the Systems Analysis function is crucial for controlling the requirements process in the ASTP. If inappropriate requirements are allowed to creep into the program, it could result in "business-as-usual" rather than the innovative approaches that are essential to the success of the program.

3.3 Technology Development Management

The technology development management role requires preparing technology development contracts, reviewing the technology development, and managing the transfer of the technology in a timely manner to support the on-orbit technology demonstrations.

3.3.1 Technology development Contracts

Technology development contracts require preparation of the solicitation packages, definition of the source selection process and the selection criteria, and contract management, following contract award.

3.3.2 Technical Reviews

The technical reviews for technology development contracts require management oversight to ensure that the work meets the performance and cost objectives of the ASTP program.

In addition, the technical progress must be maintained to meet the technology transfer schedule to support the on-orbit demonstrations. The technologies are needed to achieve performance at lower cost and weight, which should be the major emphasis of the design reviews. Reduction of cost drivers without impairing the performance should be addressed directly in each technical review. Additionally, the lightweight emphasis must be maintained to ensure that significant weight reductions are achieved through the technology development.

3.3.3 Technology Transfers

The technology transfers may be required to support on-orbit technology demonstrations. Therefore, the technology transfer planning must coordinate with the on-orbit technology demonstration management area to determine the transfer schedule. Technology transfers must be coordinated with the prototype development management area as the time approaches to ensure that the transfers meet the needs of prototype development.

3.3.4 Roles and Responsibilities - Technology Development Management

The management of technology development and subsequent technology transfer to prototype development is the traditional role of DARPA. The recent changes in DoD procurement policy permit DARPA to award and manage contracts

directly instead of participating with other procurement organizations. As additional restrictions continue to be placed on the contracting process, the time required to award contracts has become in excess of a year at most service contracting organizations. This could have a serious impact on a program which is planned for a five year duration. To assure that ASTP technology contracting receives the highest priority, DARPA should retain control of the Technology Development Management function. Existing technology development projects that apply to the ASTP should focus on the needs for on-orbit technology demonstration schedules. The tasks can be delegated to the Department of Defense (DoD) laboratories and probably will be shared with them when all technology development projects have been identified. If a technology development is intended to support an on-orbit technology demonstration directly, the planning process should treat it as a prototype development effort and include the additional tasks required on prototype development contracts.

3.4 Prototype Development Management

The prototype development management role requires preparation of development or production contracts for launchers, launch support modifications, satellite buses, payloads, tasking support modifications, ground data processing modifications, and satellite ground support modifications.

Each of these contracts must be managed to support design reviews, monitor development status, and take corrective action when potential problems arise.

3.4.1 Prototype Development Contracts

The preparation of the contracts for prototype development requires the normal solicitation package, source selection support, and management of the ensuing development. In addition, new contracts must be prepared, or existing contracts must be modified to make changes to existing operational elements for support of the on-orbit technology demonstration. Other existing support elements, such as the launch facilities and the Satellite Control Facility, require identification of support requirements rather than development contracts.

3.4.2 Prototype Development Contract Management

Each of the development, production, or modification contracts must be managed to ensure that the designs meet the requirements, that the development remains on schedule, and that each development will converge with the others at completion. The identification and reduction of cost drivers will be required to achieve the low recurring cost objective of the program. Seven separate elements are required for each on-orbit technology demonstration. The seven elements and the alternative contracting methods are shown in the following table. Prototype development of the elements of the on- orbit technology demonstrations will require all new development of some elements or major modifications to existing systems for other elements. New development will be required for the satellite bus and payloads. Both new and existing launchers are required. The existing demonstration support elements such as launch support and ground systems will require prototype modifications.

ELEMENT	CONTRACT	DEV. TYPE	COMMENTS
Satellite Bus	New	New	May Use Existing
Payload	New	New	Several Required
Launcher	New/Mod	New/Mod	Several Types Used
Launch Support	Mod	Mod	Use Existing
Tasking	Mod	Mod	Use Existing
Satellite Gnd Spt	Mod	Mod	Use Existing
Gnd Data Proc	Mod	Mod	Use Existing

3.4.3 Roles and Responsibilities - Prototype Development Contract Management

Prototype development should be delegated to the military procurement organizations, for security reasons and because this is where the development management experience can be found. Each of the separate development efforts in the ASTP program plan may be delegated to a different organization. DARPA could play a lead role in the coordination of these efforts or simply provide oversight. If DARPA retains the Program Management and Systems Engineering roles, as has been recommended, DARPA should provide both a management and technical oversight function to ensure that the several separate development efforts are converging according to the ASTP Program Plan. The culmination of the prototype development efforts will provide several separate completed parts of the on-orbit demonstration system that require assembly and integration. The development contracts must include support tasks for system integration and on-orbit demonstration operations.

3.5 Systems Integration

The system integration role requires integration planning and coordination, interface engineering, ground system integration, launch system integration, and flight readiness preparation for the on-orbit demonstrations. The integration of the products of technology development and prototype development with the modified demonstration support systems is required since several different organizations will be involved in the development process. The flight readiness review follows completion of development and integration of the individual elements and verifies the total system prior to launch of the satellite. Since the simulation of some system elements may be necessary during this process, another prototype development issue must be addressed.

3.5.1 Integrated Test Planning

The planning of the test program leading to the on-orbit demonstrations identifies the test objectives, assigns the roles and responsibilities for testing, identifies test support requirements, and coordinates with the development organizations to ensure that the plan is being followed.

3.5.2 Interface Engineering

Interface engineering is required to ensure that the design and development process continues to address the interface requirements and that the designs support a compatible interface with the other elements.

3.5.3 Launch System Integration

Launch system integration is the function that receives the payload, satellite bus, launcher, and all of their support equipment, and assembles them into the launch vehicle at the launch site. Planning for launch system integration requires that the interfaces be coordinated thoroughly prior to shipment of the equipment to the launch site.

3.5.4 Ground System Integration

Ground system integration begins when the development products have been installed at the operating sites, and each of the elements has been tested individually. The separate elements of the ground system are tested together to ensure that the system requirements are met and that the interfaces operate correctly. The interfaces with the integrated launch vehicle may be tested either with simulators or with the actual launch vehicle.

3.5.5 Flight Readiness Preparation

Flight readiness preparation begins during system integration and continues through the flight readiness review. The flight readiness preparation tests the system, identifies the discrepancies and deficiencies that must be corrected prior to flight, and supports the correction of the items according to a priority order. The final ordeal is the flight readiness review where an independent group reviews all of the readiness data and determines, if any, additional activities are required before launch. The technical approach is likely to be driven by the policies of the support organizations such as the National Ranges or the Satellite Control Facility. Their flight readiness process requires a rigorous verification of system capabilities prior to actual operations. The technical approach for flight readiness must follow the normal development, integration, flight readiness process to be accepted as a sound plan, and to avoid on-orbit failures which could seriously undermine the ASTP concept. The low-cost approach must be integrated with the normal flight readiness process as a means of proving the validity of the approach. For example, the low cost flight readiness approach could be performed first, followed by the normal readiness procedures. Comparing the results of the two flight readiness processes with the actual flight results can provide validation of the new approach. The subsequent on-orbit demonstrations could then approximate the actual low-cost operations that are being demonstrated. During operational use, in support of theater commanders, the emphasis should be on creating the minimum flight readiness review process to maximize responsiveness and minimize cost.

3.5.6 Roles and Responsibilities - Systems Integration

This role could be taken by DARPA as a logical extension of the Program Management and Systems Engineering roles. But, Air Force Space Division (AFSD) and NASA have the most government based experience performing the launch system

integration, launch support services for on-orbit demonstrations, and the flight readiness process. They should be considered for the System Integration responsibility. However, these organizations may not be comfortable with the innovative, low-cost approach. DARPA must be aware of this problem as it performs its Program Management and Systems Engineering functions.

3.6 On-Orbit Technology Demonstration Management

The on-orbit technology demonstration management role requires demonstration planning, demonstration support coordination, demonstration preparation and conduct, and data analysis and reporting.

3.6.1 On-Orbit Demonstration Planning

The on-orbit demonstrations should be planned as a system of demonstrations rather than a single demonstration. The initial demonstrations should be considered engineering flight tests of lightweight payloads and may use existing satellite bus and launcher technology to provide engineering feedback, as well as demonstration of military utility. Later demonstrations that represent engineering flight tests of the lightweight satellites may include the improved lightweight payload with the lightweight satellite bus using an existing launcher. The ultimate demonstration following all of the technology transfers should use the final configuration of the lightweight payload, the final configuration of the lightweight satellite bus, and the low-cost launcher. Both peacetime and conflict military utility should be demonstrated. A separate demonstration plan will be prepared for each payload type to be demonstrated for military utility. The subsequent uses of the same plan for later flights will refine the procedures and eventually demonstrate the low- cost, effective operations being sought.

3.6.2 Demonstration Support Coordination

The on-orbit technology demonstrations will require support from several government agencies and organizations. Launch support will be required for one or more launch sites to prepare the integrated launcher and satellite for launch, verify its readiness for flight, and launch the satellite into orbit. Tasking support will be required to plan the operations of the satellite in response to the military user's requirements.

Satellite ground support will be required to control the satellite in orbit, transmit commands to perform the required payload functions, and process telemetry to verify correct operation of the satellite during the demonstration. The traditional support organizations normally require considerable lead time to respond to new requirements, and the coordination process is not yet streamlined. The technical approach for the coordination of support should follow the normal process for the support organizations but identify the short cuts in the process to achieve the low-cost objective. Subsequent demonstrations with the same support organization will provide insight into the possible short cuts that may be taken for low-cost operations.

3.6.3 Demonstration Conduct

Management of the conduct of the demonstration requires on-site direction of the course of the demonstration. Each of the participating

elements must be monitored for performance to ensure that only normal system performance is being evaluated for military utility. The system operations should approximate normal military operations during the demonstration. The demonstration may continue through the orbital lifetime of the satellite and will require several crews to sustain the direction.

3.6.4 Data Analysis and Reporting

The data obtained in the course of the demonstration must be analyzed for military utility and for any deficiencies that should be corrected prior to the next demonstration flight. Rapid feedback for planning the next demonstration is required to incorporate lessons learned from the previous demonstrations. The reports issued at the completion of data analysis must be prepared and presented to appropriate government agencies.

3.6.5 Roles and Responsibilities - On-Orbit Technology Demonstration Management

The on-orbit technology demonstration planning and data analysis is closely associated with the military operations being supported, hence should be delegated to a lead DoD service or agency. DARPA should retain an oversight role to ensure the validity of the demonstration. The on-orbit demonstration support coordination activities should be delegated to the military procurement organizations where this type of coordination is performed for other space programs. DARPA should retain program oversight to maintain control of the ASTP program. The lead role in the conduct of the demonstration should be delegated to the same lead DoD service or agency that performs the planning and data analysis.

4. SUMMARY

The technical approach discussed above describes alternatives for the DARPA responsibility for each of the six major task areas in the ASTP program. Figure 5 is a summary of the assignment of responsibility for each major task area, as recommended in the body of the report. It also shows the SETA level of effort, in manyears, associated with discharging each of the areas of responsibility. It should be noted that the SETA requirement will not change substantially as a result of delegation of responsibility. The SETA support will be required instead by the organization to whom the delegation has been made. The impact on the DARPA SETA, of assigning responsibility differently from the recommendations in the report, can be assessed by merely adding or subtracting the manpower level of effort required for the given task area.

There are managerial and technical tasks to be pursued at the program level. The division of these responsibilities is seldom attempted since technical achievement is as important as cost and schedule performance, and is a major determinant of cost and schedule. It is recommended that in order to avoid the risk of "space business-as-usual", DARPA retain the program management and systems engineering responsibilities and the lead role in technology development. DARPA should delegate the prototype development management and system integration to military procurement organizations. DARPA should delegate on-orbit technology demonstration management to a lead DoD service or agency with support coordination delegated to the military procurement organizations. There should be no case where delegation occurs without DARPA oversight if DARPA retains program management responsibility. If program management responsibility is delegated, the DARPA role, and consequently the SETA requirement will be reduced only to technology development management. The other tasks will be performed by the delegated organizations with their own SETA support.

	DARPA PROGRAM OFFICE	DARPA AGENT DOD PROCUREMENT ORGANIZATION	DOD USER	SETA LEVEL OF EFFORT
PROGRAM MANAGEMENT	√			3
SYSTEM ENGINEERING	√			8
PROTOTYPE DEVELOPMENT				5
SATELLITE BUS		√		
PAYLOAD		√		
LAUNCHER		√		
LAUNCH SUPPORT			√	
TASKING		√		
SATELLITE GROUND SUPPORT			√	
GROUND DATA PROCESSING		√		
TECHNOLOGY DEVELOPMENT	√	√		6
SATELLITE BUS				
PAYLOAD				
LAUNCHER				
GROUND SYSTEMS				
SYSTEM INTEGRATION				10
LAUNCH SYSTEM			√	
GROUND SYSTEM		√		
FLIGHT READINESS		√		
ON-ORBIT DEMO MANAGEMENT				6
DEMO PLANNING			√	
SUPPORT COORDINATION		√		
CONDUCT			√	
DATA ANALYSIS & REPORTING			√	
SETA PROGRAM MANAGEMENT	√			9

Figure 5. Alternative DARPA Approaches